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# Tagging Studies on Eastern Georges Bank Yellowtail Flounder

# Études de marquage sur la limande à queue jaune de l'est du banc Georges

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## ABSTRACT

A joint DFO Science/Industry tagging project was initiated in 1999 to obtain up-to-date information on transboundary migration patterns, seasonal geographic distribution, stock structure and growth rates of eastern Georges Bank yellowtail flounder. In 1999, 2,155 yellowtail were tagged and released in Canadian waters in the "Yellowtail Hole" on southeastern Georges Bank. In 2002 and 2003, 452 and 364 tagged fish were released in US waters within Closed Area II near the Canada/USA International Boundary Line. Of 108 recaptures with location information from the Yellowtail Hole releases in 1999, nearly all (106) were caught in the Yellowtail Hole over a four year period from 2000-2003. One moved to the northeast peak of the Bank, and one moved to the northern edge of the Bank in US waters. Nineteen yellowtail flounder recaptures were reported from the Closed Area II releases in 2002 and 2003. All were from Canadian yellowtail directed trips in the Yellowtail Hole area during the 2002/2003 commercial fishery. Results from these studies support findings from earlier tagging experiments, and indicate that yellowtail flounder on eastern Georges Bank undertake limited movements with a possible seasonal component. They also undertake transboundary movements to the east and west across the international boundary, confirming that the current 5Zhjmn management unit recognized by both Canada and the USA is appropriate for this stock.



## RÉSUMÉ

En 1999, le secteur des Sciences du MPO et l'industrie ont lancé un projet conjoint de marquage de la limande à queue jaune de l'est du banc Georges pour obtenir une mise à jour des données sur ses migrations transfrontalières, sa répartition géographique saisonnière, sa structure de stock et ses taux de croissance. En 1999, 2 155 limandes à queue jaune ont été marquées et relachées dans la partie méridionale du banc Georges connue sous le nom de « Yellowtail Hole ». En 2002 et en 2003, respectivement 452 et 364 limandes marquées ont été relachées dans la zone II fermée, dans les eaux américaines près de la frontière avec le Canada. Des 108 recaptures (avec des données de localisation) de poissons marqués au Yellowtail Hole en 1999, presque tous (106) ont été pêchés au Yellowtail Hole de 2000 à 2003. Une des deux autres recaptures a été faite à la pointe nord-est du banc Georges, et l'autre, à la bordure nord du banc, en eaux américaines. Dix-neuf recaptures de limandes marquées en 2002 et en 2003 dans la zone II fermée ont été signalées. Ces poissons ont tous été pris par des pêcheurs commerciaux canadiens lors de sorties de pêche dirigée de la limande à queue jaune dans le secteur de Yellowtail Hole durant la saison 2002-2003. Les résultats de ces études, appuyant ceux d'expériences de marquage antérieures, indiquent que la limande à queue jaune de l'est du banc Georges effectue des déplacements limités, possiblement de façon saisonnière. Ce poisson traverse aussi la frontière canado-américaine dans un sens est-ouest, ce qui confirme que l'unité de gestion 5Zhjmn actuellement reconnue par les autorités canadiennes et américaines convient à ce stock.

## INTRODUCTION

In 1993, a directed Canadian fishery for yellowtail flounder (*Limanda ferruginea*) began on Georges Bank, pursued mainly by small otter trawlers (< 20 m). Since 1993, the fishery for this resource has rapidly expanded and over the past five years (1999-2003), annual landings (excluding discards) have averaged 2,500 t. The Georges Bank stock is a transboundary resource and is fished by both Canada and the USA. Commercial exploitation of yellowtail flounder by the USA trawler fleet began in the mid-1930s, with annual landings being considerably lower in recent years (average = 2,800 t for 1998-2002) compared to the high levels of the 1960's and 1970's (average = 13,000 t for 1963-1976). Tagging observations, larval distribution patterns, life history traits, and geographic patterns of landings and survey data indicate that Georges Bank yellowtail flounder comprise a relatively discrete stock, separate from those occurring on the western Scotian Shelf, off Cape Cod and southern New England (Lux, 1963; Neilson et al., 1986). While the current management unit recognized by both nations (5Zjhmn) includes the entire bank east of the Great South Channel to the Northeast Peak (Fig. 1), the extent of yellowtail flounder movement within this area is not well understood.

Only two tagging studies have been conducted on Georges Bank yellowtail flounder and these were done over forty years ago, long before the establishment of a maritime boundary between Canada and the USA in 1984 and the development of a Canadian fishery in 1993. Royce *et al.* (1959) tagged and released 340 yellowtail flounder on Georges Bank in 1946 (north of Cultivator Shoal) and 1949 (Southern Flank) and recovered 52 tags (16%) over a six-year period (1946-1952) (Fig. 1). Nearly all of the recaptures of fish released on Georges Bank occurred in the same area, but three moved westward across the Great South Channel and were recovered off southern New England in winter, south and west of Nantucket Island. Royce *et al.* (1959) concluded that groups of yellowtail flounder are relatively localized with little mixing among fishing grounds, but are capable of short seasonal migrations. Lux (1963) tagged and released 430 yellowtail flounder on Georges Bank within NAFO Statistical Area 5Zm in 1957 and recovered 121 tags (28%) over three years (1957-1960) (Fig. 1). Nearly all of the fish that were released on Georges Bank were recaptured in the same area (96%), but five were recovered off southern New England in winter. Lux (1963) concluded that while there was some movement to the westward during winter months and eastward in summer, there was no clear migration pattern on the bank itself and most recaptures occurred in the area of release.

To obtain more current information on migration patterns, seasonal geographic distribution, stock structure and growth rates, a co-operative tagging project on eastern Georges Bank yellowtail flounder was initiated in 1999 involving Canadian scientists from the Department of Fisheries and Oceans and the Canadian groundfishing industry (Scotia Fundy Mobile Gear Association). This project involved tagging yellowtail flounder in an area known by fishermen as the "Yellowtail Hole" where the Canadian commercial fishery takes place (Fig. 1). One of the main areas of interest from the perspective of the Canadian industry, and in terms of defining the appropriate geographic management area, was to determine if there is any movement of tagged fish across the international boundary line (i.e. from the Canadian side to the US side or *visa versa*). The area on the USA side adjacent to the Canadian fishery (Closed Area II; Fig. 1) has been closed year-round to all

commercial fishing operations since 1995 with the exception of an offshore sea scallop "exemption" fishery which took place in 2000. While yellowtail flounder represented a significant bycatch in this fishery, no recaptures of fish tagged in the "Yellowtail Hole" have been reported. To investigate potential transboundary movements from the US side to the Canadian side, yellowtail flounder were tagged in the closed area during the 2002 and 2003 Georges Bank bottom trawl surveys conducted by the Canadian Department of Fisheries and Oceans (DFO). This report provides an interpretation of yellowtail flounder movements on eastern Georges Bank based on results of recaptures from 2000-2003 for fish tagged in 1999, 2002 and 2003.

## METHODS

Yellowtail flounder used for tagging studies were captured and released on three separate occasions (Fig. 1). The first and largest group ($n$ = 2,155) was tagged and released on northeastern Georges Bank on the 13$^{th}$ and 14$^{th}$ of December, 1999, aboard the 20 m fishing vessel *Carmelle J*. These fish were collected over a 24 hour period from fifteen 10-minute tows using standard commercial gear (Balloon 300 bottom trawl with 155 mm square mesh cod end) (Table 1). All tows were conducted on prime commercial fishing grounds in the Yellowtail Hole at depths of 78-80 m. When the gear was retrieved, the cod end was opened and all fish were released directly into a holding tank filled with running ambient seawater. Using a dip-net, yellowtail flounder were removed from the holding tank, measured for total length (TL, nearest cm), tagged and then released over the side while the vessel maintained its position until all fish in the tank were tagged and released. Since the Canadian portion of the management area is closed from 1 January through to 31 May, it was assumed that tagged fish would disperse over the fishing grounds without interference from commercial fishing operations until the fishery opened on 1 June.

The second ($n$=452) and third ($n$=364) groups were tagged on 23 February, 2002 and 22 February, 2003 aboard the 47 m research vessel *Alfred Needler* during annual spring bottom trawl surveys conducted on Georges Bank by DFO. These fish were collected from 10-minute tows using a Western IIA bottom trawl with a 10 mm mesh liner in the cod end. Tows were conducted in US waters (71-78 m depth) within an area closed year-round to commercial fishing (Closed Area II) (Fig. 1; Table 1). When the gear was retrieved, the cod end was opened and all fish were released directly into a stainless steel chute that opened onto a conveyor belt located in the wet lab below the trawl deck. These fish were then immediately transferred to a holding tank with running ambient seawater. Yellowtail flounder were removed from the tank with a dip-net, measured (TL), tagged and then released though a scupper in the side of the vessel. The tagged fish were released at locations within 10 and 21 km from the international boundary line in 2002 and 2003, respectively (Fig. 1).

Yellow plastic T-bar FLOY tags (7 cm long) were supplied by FLOY Tag and Manufacturing Inc. (4616 Union Bay Place NE, Seattle WA 98105). Tags were applied using a *Dennison Mark II* tagging pistol with a 3.5cm needle that was inserted into the back musculature directly below the dorsal fin on the right side. Insertion depth varied with fish size, but generally the tags were applied so that they would penetrate the hemal spines. Any

fish showing injury or lethargy were not tagged. It was assumed that injuries caused by the capture method would be minimized by conducting short tows (10 min) at shallow depths (i.e. <81 m), when water temperatures were low (i.e. in December and February). Tags were labelled with an identification number, a notification of reward and a return address for both Canada and the United States, since it was anticipated that some recaptures could occur in US waters.

Posters advertising the tagging project and a tag reward were placed at various fish processing plants in southwestern Nova Scotia (Canada) and in the state of Massachusetts (USA). Recapture participants were responsible for providing information on the recapture date, fish size (TL, cm) and the method and location (latitude, longitude) of capture. All participants received a reward (Yellowtail Flounder Tagging Cap) and a letter summarizing details on the release and recapture (i.e. dates, location, fish size, distance travelled).

An algorithm based on spherical geometry was used to calculate the straight line minimum distance (nearest km) between release and recapture latitude and longitude co-ordinates. Bottom trawl fishing effort data (hours fished) for cod, haddock or yellowtail flounder directed trips on northeastern Georges Bank (2000-2003) were aggregated by 5 minute rectangles of latitude and longitude and plotted for comparisons with the distribution of tag returns. Effort was plotted only for those trips that occurred during the same months when there were tag returns, however, for 2003, effort data was only available up to October. The relationship between length at release (cm) and distance travelled per month from the release site (km/month) was examined by linear regression to determine if the rate of dispersal was influenced by fish size. A *ln* transformation was applied to the distance per month data to minimize variance.

To investigate potential seasonal trends in the number of recaptures, nominal catch rates of yellowtail flounder (t/hr) were calculated by month for mobile gear trips in 5Zm with ≥ 2 tonnes of yellowtail landed per trip during the recapture period (2000-2003) and for the entire Canadian fishery (1993-2003). These criteria were used to select what were considered to be only directed yellowtail flounder fishing trips.

An instantaneous estimate of the "loss rate" or decline in returns over time for yellowtail flounder releases in the Yellowtail Hole was calculated from the slope of the regression of recapture year (2000-2003) on the *ln* transformed number of recaptures (Ricker, 1975; p105). For Closed Area II releases in 2002, loss was estimated from the difference between the *ln* transformed number of recaptures for 2002 and 2003. Since fish from the Yellowtail Hole and Closed Area II are from an open population, an instantaneous movement rate from these areas can be calculated as:

Movement = Loss - F - M

where F~0.5 and M=0.2, based on results from the most recent analytical assessment of the Georges Bank stock (Stone and Legault, 2003). While several factors may affect these calculations including tag loss, tagging mortality, reporting rate and varying levels of F and

M, it is assumed that these estimates are sufficient for illustrating differences in movement/emigration from the two areas.

## RESULTS

### *Yellowtail Hole Releases in 1999*

In total, 123 recaptures (5.7% of total releases) were reported from the Yellowtail Hole releases in 1999, most of which occurred during the 2000 fishing season ($n$ = 88), dropping off sharply in 2001 ($n$ = 21), 2002 ($n$ = 10) and 2003 ($n$ = 4). Nearly all the recovered tags (98%) were found in Canadian bottom trawl catches from yellowtail flounder directed trips in 5Zm, either on board commercial fishing vessels or in fish plant cutting rooms. While the distribution of mobile gear fishing effort for cod, haddock and yellowtail trips covered most of the Canadian portion of the bank (5Zj and 5Zm), yellowtail recaptures during the 2000-2003 fishing seasons were concentrated mainly in the Yellowtail Hole area (Figs. 2a and 2b). Canadian recaptures occurred in June and during the third (July-August) and forth (September-December) quarters of the year since the Canadian portion of Georges Bank is only open to commercial fishing from 1 June to 31 December. Only two recaptures occurred outside 5Zm, one in Canadian waters (August, 2000) near the northern edge of the bank (5Zj), and one in US waters (May, 2002) reported by a fisheries observer deployed on a US trawler fishing just outside the closed area (5Zj). This was the only recapture reported in USA waters over four years from 2000-2003.

Information on recapture date and location (i.e. latitude and longitude) was reported for 97% and 86% of returns, respectively. Time at large ranged from 183-1388 days (mean ± sd = 420 ± 293.2), while distance from release positions ranged from 0.0-94.2 km (mean ± sd = 10.2 ± 11.54) (Table 2). Sixty-four percent of all reported recaptures occurred within 10 km of the release positions. However, there was a slightly increasing trend from 2000 to 2003 in the annual mean distance travelled from the release position (mean = 9.1 km for 2000, 10.3 km for 2001 and 17.9 km for 2002, 11.8 km for 2003; Table 2). The higher mean distance for 2002 was largely influenced by the single recapture from US waters, which was the maximum distance reported in this study (94.2 km). Noteworthy were two recaptures in 2000 which occurred at the exact location as the release co-ordinates in December 1999.

When recapture information was pooled for all four years (2000-2003), a slight seasonal trend was apparent in the mean distance travelled by month of recapture. Recaptures during May and June occurred at a greater mean distance from release positions (94 and 33 km, respectively) compared to recaptures reported for July, August, September, October and December (all < 10 km from the release location) (Fig. 3). The May recapture (2002) was reported in US waters outside of the closed area (Fig. 2b, upper panel), while the June recaptures (2000) were all reported in Canadian waters from 5Zm near the international boundary (Fig. 2a, upper panel). There was also one recapture 59.4 km from the release location reported in August 2000 from 5Zj (Fig. 2a, upper panel).

Yellowtail flounder tagged and released in 1999 ranged in size from 22-49 cm TL (mean ± sd = 34.9 ± 3.13 cm TL) (Fig. 4). Information on length at recapture was available for 107 fish (87% of returns), and these fish ranged in size from 30-45 cm TL (mean ± sd = 36.2 ± 3.05 cm) (Fig. 4). The growth increment (cm) during the time at liberty was calculated by subtracting the length at release from the length at recapture. However, differences between release and recapture measurements revealed a large degree of measurement error, particularly during the 2000 and 2001 fishing seasons, with many fish showing no increase in length, or a decrease in length during the time at large (Fig. 5). The 2002 and 2003 recapture length measurements were considered to be more accurate, since most fish were known to be measured by DFO port sampling technicians. Based on differences between release and recapture lengths for the 2002 and 2003 returns, the average increase in size was 3.4 ± 2.98 cm over 2.5-2.9 years and 3.3 ± 2.52 cm over 3.7-3.8 years, respectively, and is equivalent to an annual increment of 0.8-1.2 cm per year. However, because the sample size used in these calculations is quite small and measurement error is a major concern, the data were not considered reliable for accurate estimation of an annual growth increment.

The influence of size at release on distance travelled per month from the release location was examined by linear regression (Fig. 6). The slope of the regression was not significantly different from zero ($P$= 0.270, t=1.109, df=105) and the correlation coefficient was very low ($r$=0.108). Therefore, the distance travelled from the release location or rate of dispersion was not influenced by fish size.

### *Closed Area II Releas[illegible] 2002 and 2003*

Ten yellowtail flounder recaptures (2.2% of total releases) were reported in Canadian waters from the February 2002 tagging experiment in Closed Area II. Most were from directed Canadian yellowtail flounder fishing trips in 5Zm, with 8 recaptures reported in 2002 and 2 reported in 2003. Information on recapture date and position (latitude and longitude) was available for 8 fish, all of which undertook transboundary movements from the US side of the management area to the Canadian side (Fig. 7). For these fish, the time at large averaged 263 ± 156.1 days, while distance from the release positions averaged 25.7 ± 4.11 km (Table 2). Notable is the one recapture reported from 5Zj in June 2003, which occurred 53 km from the release point.

Nine transboundary recaptures (2.5% of total releases) were reported in 2003 in Canadian waters from the February 2003 tagging experiment in Closed Area II. Most of these occurred in the Yellowtail Hole (5Zm), although two were reported on or near the 5Zj/5Zm boundary; one in June and one July (Fig. 8). On average, recaptured fish from this experiment were at large for 151 ± 40.9 days and had moved 29.2 ± 14.42 km from the release site (Table 2).

The overall mean distance travelled for Closed Area II releases was greater than that reported for Yellowtail Hole releases (Table 2). As in the case of the Yellowtail Hole releases, a slight seasonal trend was apparent, with more distant recaptures occurring in

June and July (mean ± sd = 36.9 ± 15.81 km; $n$=5) compared to August, September and October (mean ± sd = 21.1 ± 3.46 km; $n$=11) (Fig. 9).

Yellowtail flounder tagged and released in Closed Area II in 2002 ($n$ = 452) ranged in size from 25-52 cm TL (mean ± sd = 36.2 ± 3.05 cm TL) (Fig. 10a). Length at recapture was reported for 8 fish, and ranged from 35-44 cm TL (mean ± sd = 38.0 ± 3.25 cm). Yellowtail flounder released in the closed area in 2003 ($n$ = 364) ranged from 26-50 cm (mean ± sd = 37.9 ± 4.12cm) (Fig. 10b). Length at recapture was reported for 9 fish, which ranged in size from 35-39 cm TL (mean ± sd = 36.3 ± 2.91 cm). The average increase in size during the time at large was not calculated for the closed area releases due to the large degree of measurement error in reported lengths at recapture.

### *Mobile gear Catch Rates*

Mobile gear catch rates for trips with ≥ 2 t of yellowtail landed in 5Zm during the recapture period (2000-2003) and for the entire fishery (1993-2003) were generally low at the beginning of the fishing season in June, followed by a general increase to September then a continuous decline through to December (Fig. 11). This pattern suggests that the relative abundance of yellowtail flounder in 5Zm may be low when the fishery commences in June, high during summer months and then declines in the fall, possibly due to fishery removals.

### *Estimates of Movement and Emigration*

For Yellowtail Hole releases in 1999, the regression of $ln$ returns by year (2000-2003) was significant ($P$=0.010, F=96.323, df=1, 2), and highly correlated ($r$=0.99) (Fig. 12). The slope of this relationship indicates a loss rate of -1.0. Assuming that Loss=-0.1, F=0.5 and M=0.2, the movement rate out of the Yellowtail Hole in any direction is -0.3 or approximately 26% annually (i.e. $1\text{-}e^{-0.3}$). For the Closed Area II releases in 2002, loss was estimated as -1.386 (i.e. 8 returns in 2002 and 2 returns in 2003; or $ln(8)$-$ln(2)$). Assuming that F~0, since there is no fishing activity within the closed area, and M=0.2, this would give a net movement rate of -1.2 to areas adjacent to Closed Area II, which would be greater than 50% per year.

## DISCUSSION

Since the recaptures in our study were dependent on commercial fishing operations, the distribution and abundance of recaptured fish is a function of the distribution of fishing effort as well as fish movement. On northeastern Georges Bank, the potential for recapture was constrained both seasonally and geographically by management measures aimed at limiting fishing effort (i.e. year round closure of Area II on the US side and a January-May closure on the Canadian side). While there were some opportunities for tag returns within Closed Area II, i.e. during the sea scallop "exemption" fishery in 2000 (25% observer coverage), and the bottom trawl studies conducted by the Manomet Center for Conservation Studies in 2002 and 2003 (100% observer coverage), no Canadian tagged fish were recaptured in this area. Notwithstanding this, the results of our study generally

support those of earlier tagging experiments conducted by Royce *et al.* (1959) and Lux (1963) and indicate that yellowtail flounder on northeastern Georges Bank undertake localized movements with a possible seasonal component. They also clearly undertake transboundary movements to the east and west across the international boundary line, confirming that the current 5Zhjmn management unit recognized by both Canada and the USA is appropriate for this stock.

Previous tagging studies on Georges Bank yellowtail flounder have yielded higher return rates than what we report for fish tagged in the Yellowtail Hole after nearly four years at liberty (i.e. 5.7%). Royce *et al.* (1959) reported a 16% return rate over a 6 year period (1946-1952), while Lux (1963) reported a return rate of 28% over three years at large (1957-1960). Both studies used Peterson disc tags, which may have better retention rates on flatfish than the T-bar FLOY tags used in our study. Although FLOY tags can be applied quickly and easily, the anchor should penetrate the hemal spines in the musculature below the dorsal fin, or the tags may work their way out over time. Peterson disc tags are attached to each side of the nape of the fish below the dorsal fin with a stainless steel pin, which passes through the musculature and is looped over each disc with pliers. To address the issue of T-bar tag loss, 200 yellowtail flounder were tagged on northeastern Georges Bank in February, 2004, with both Peterson disc tags and T-bar FLOY tags and released in the Yellowtail Hole. It is anticipated that this study will provide new information on T-bar tag retention and loss in flatfish. While tag loss may have influenced the results of our study, lack of reporting in some instances may also have occurred, particularly in US waters where fishermen may be less inclined to report a Canadian tagged fish due to concerns over national catch allocations (S. Cadrin, National Marine Fisheries Service, Woods Hole MA, 02543, personal communication).

Both Royce *et al.* (1959) and Lux (1963) reported more distant recoveries of Georges Bank yellowtail flounder during winter months. While there may be a seasonal component to the movements of yellowtail flounder on northeastern Georges Bank, it is difficult to confirm this from the tag returns in our study. Commercial fishery catch rates for directed yellowtail flounder trips in 5Zm during the recapture period (2000-2003) and for the entire Canadian fishery (1993-2003) indicate that relative abundance may be low when the fishery begins in June (Fig. 11). This trend raises the possibility that yellowtail flounder may be more dispersed outside of the Yellowtail Hole area at the time when the more distant recaptures were reported. Most of the mobile gear trips on northeastern Georges Bank in June are directed for haddock, although some catches of yellowtail do occur. As the season progresses, there is an increase in the proportion of yellowtail flounder catches in and around the Yellowtail Hole as more trips are directed for this species. Since 2002, all vessels directing for haddock on Georges Bank are required to use a separator panel in the bottom trawl to reduce cod bycatch. The panel may also reduce catches of yellowtail flounder, especially in 5Zj where the haddock fishery is largely concentrated, further reducing the potential for more distant recaptures early in the fishing season. Confirmation of seasonal movements will require further investigation by tagging fish at locations beyond perimeter of Yellowtail Hole.

For the Yellowtail Hole releases, there was no relationship between size at release (29-44 cm TL) and rate of dispersal over the four year recapture period. This may be due to the fact that most tagged fish were greater than the $L_{50}$ mature reported by Royce *et al.* (1959) (i.e. $L_{50}$ mature = 26cm and 32cm TL for males and females respectively) and may complete spawning and feeding activity on the same grounds. While there is currently no information on the movements of small (i.e. <25cm), immature yellowtail flounder on Georges Bank, incidental catches from annual research vessel surveys indicate that they are captured in the same areas as larger, mature fish. While other north Atlantic flatfish species such as Atlantic halibut (*Hippoglossus hippoglossus*) and Greenland halibut (*Reinhardtius hippoglossoides*) can migrate considerable distances between feeding and spawning areas (Stobo et al., 1988; Boje, 2001), yellowtail flounder on Georges Bank likely complete most their life history in a relatively small geographic area. Given the sedentary nature of this species, it is very susceptible to localized depletion from intensive exploitation and therefore careful management is required to maintain a sustainable fishery on both sides of the international boundary.

Our tag return information suggests that fish from the closed area (where F~0) likely provide an important source of recruitment to the Canadian fishery in the Yellowtail Hole. Opening Closed Area II to US commercial fishing may reduce catch rates in the Yellowtail Hole and could have important implications to the management of the yellowtail flounder fishery in Canadian waters. Canadian fishermen often conduct tows adjacent to the closed area parallel to the international boundary line where they generally achieve consistently good catch rates compared to other areas in the Yellowtail Hole (A. D'Eon, Inshore Fisheries Ltd., Middle West Pubnico, NS, B0W 2M0, personal communication) While transboundary movement in the opposite direction was also apparent from our study, the extent of emigration to the US side remains unknown.

With the implementation of a large scale yellowtail flounder tagging program by the National Marine Fisheries Service (NMFS) in 2003 and 2004, future recaptures may help to resolve the question of localized seasonal movement patterns of yellowtail flounder on northeastern Georges Bank and further contribute to our knowledge of stock structure. While results from tagging studies to date support the current 5Zhjmn management unit, new findings may support a smaller stock area (i.e. 5Zjm). Electronic data storage tags, which record measurements of depth and temperature, have been used to reconstruct the migratory tracks of North Sea plaice (Metcalfe and Arnold, 1997) in relation to hydrographic conditions, and recently have been used in studies on Grand Bank yellowtail flounder (Walsh *et al.*, 2001). Archival tags are currently being used by NMFS to investigate the daily movement patterns of Georges Bank yellowtail flounder and will hopefully provide new, more detailed information on the effects of physical oceanographic conditions on yellowtail distribution.

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Table 1. Summary of release information for yellowtail flounder tagged and released on Georges Bank in Canadian waters (Yellowtail Hole, December 1999) and US waters (Closed Area II, February 2002 and 2003).

| Release coordinates | | | |
|---|---|---|---|
| Latitude | Longitude | Number released | Depth (m) |
| | **Yellowtail Hole, December 1999** | | |
| 4134 | 6620 | 12 | 78 |
| 4136 | 6622 | 66 | 80 |
| 4134 | 6625 | 101 | 80 |
| 4136 | 6625 | 216 | 80 |
| 4136 | 6627 | 153 | 78 |
| 4139 | 6627 | 122 | 80 |
| 4135 | 6629 | 311 | 80 |
| 4133 | 6630 | 210 | 80 |
| 4138 | 6630 | 82 | 80 |
| 4136 | 6633 | 228 | 80 |
| 4134 | 6634 | 147 | 80 |
| 4136 | 6635 | 109 | 80 |
| 4135 | 6636 | 157 | 80 |
| 4133 | 6628 | 96 | 80 |
| 4133 | 6631 | 145 | 80 |
| | **Closed Area II, February 2002** | | |
| 4131 | 6641 | 200 | 71 |
| 4133 | 6644 | 252 | 71 |
| | **Closed Area II, February 2003** | | |
| 4123 | 6641 | 364 | 78 |

Table 2. Summary statistics (days at large and distance from release site) for yellowtail flounder tagged and released in the "Yellowtail Hole" (1999) and in Closed Area II (2002 and 2003).

| Recapture | Days at large | | | | | Distance from release site (km) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| year | *n* | mean | SD | min | max | *n* | mean | SD | min | max |
| **Yellowtail Hole Releases (1999)** | | | | | | | | | | |
| 2000 | 85 | 257 | 33.7 | 183 | 361 | 72 | 9.1 | 9.22 | 0.0 | 59.4 |
| 2001 | 20 | 643 | 25.8 | 605 | 681 | 20 | 10.3 | 4.56 | 1.4 | 18.1 |
| 2002 | 10 | 986 | 47.9 | 884 | 1037 | 10 | 17.9 | 27.54 | 3.3 | 94.2 |
| 2003 | 4 | 1364 | 22.3 | 1336 | 1388 | 4 | 11.8 | 3.37 | 8.5 | 15.4 |
| 2000-2003 | 119 | 420 | 293.2 | 183 | 1388 | 106 | 10.2 | 11.54 | 0.0 | 94.2 |
| **Closed Area II Releases (2002)** | | | | | | | | | | |
| 2002 | 8 | 186 | 15.4 | 169 | 214 | 6 | 21.6 | 4.11 | 15.7 | 27.6 |
| 2003 | 2 | 532 | 87.7 | 470 | 594 | 2 | 38.3 | 20.41 | 24.9 | 52.8 |
| 2002-2003 | 10 | 263 | 156.1 | 169 | 594 | 8 | 25.8 | 11.47 | 15.7 | 52.8 |
| **Closed Area II Releases (2003)** | | | | | | | | | | |
| 2003 | 9 | 151 | 40.9 | 114 | 248 | 9 | 29.2 | 14.42 | 18 | 54 |

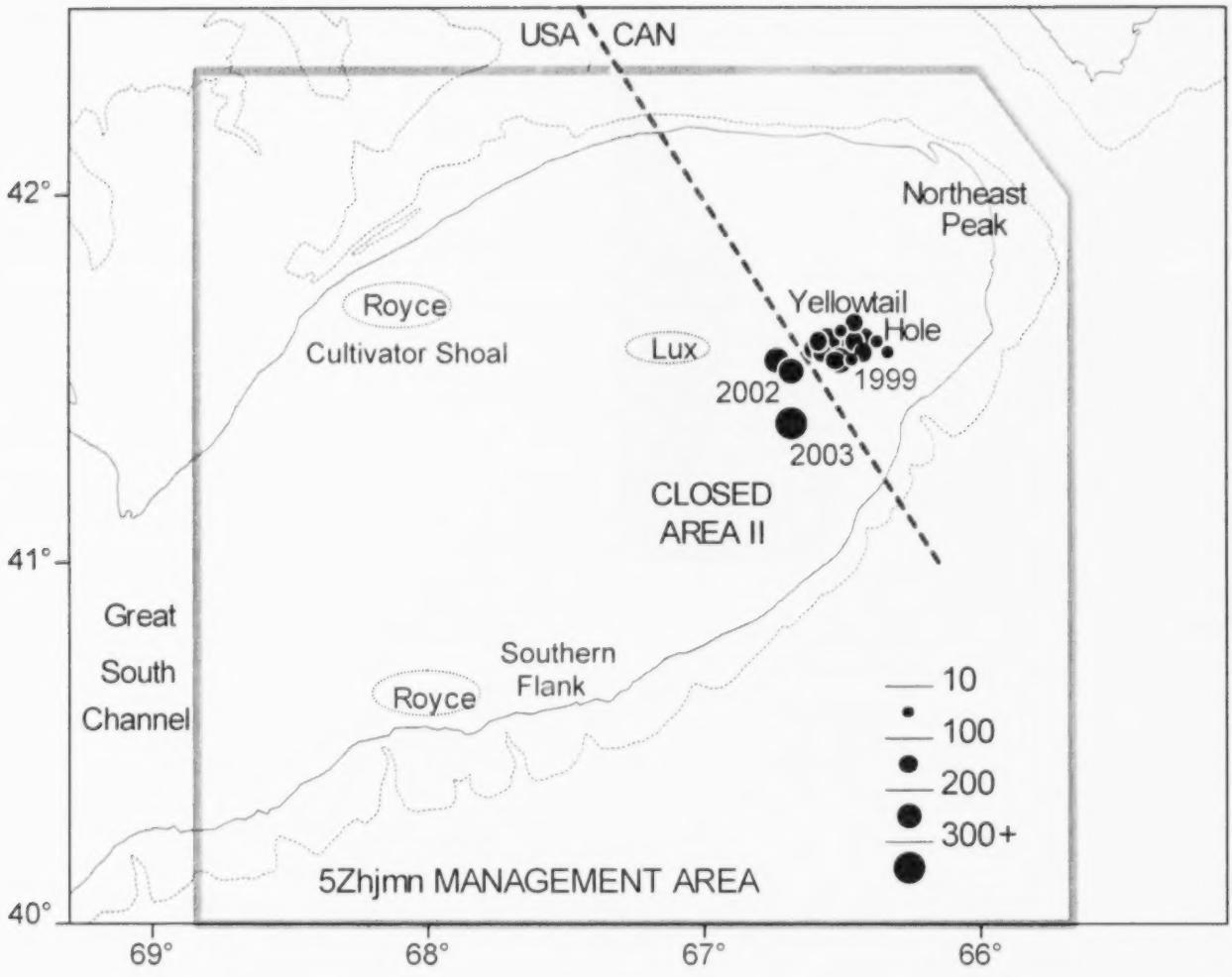


Figure 1. Map of Georges Bank illustrating the management area (bounded by grey line) for Georges Bank yellowtail flounder. the location of the international boundary (dashed line) and Closed Area II (shaded grey). Tagging locations for 1999 (Yellowtail Hole) and 2002/2003 (Closed Area II) are illustrated with expanding symbols. The release locations for yellowtail flounder tagged by Royce et al. (1959) and Lux (1963) are also shown for comparison.

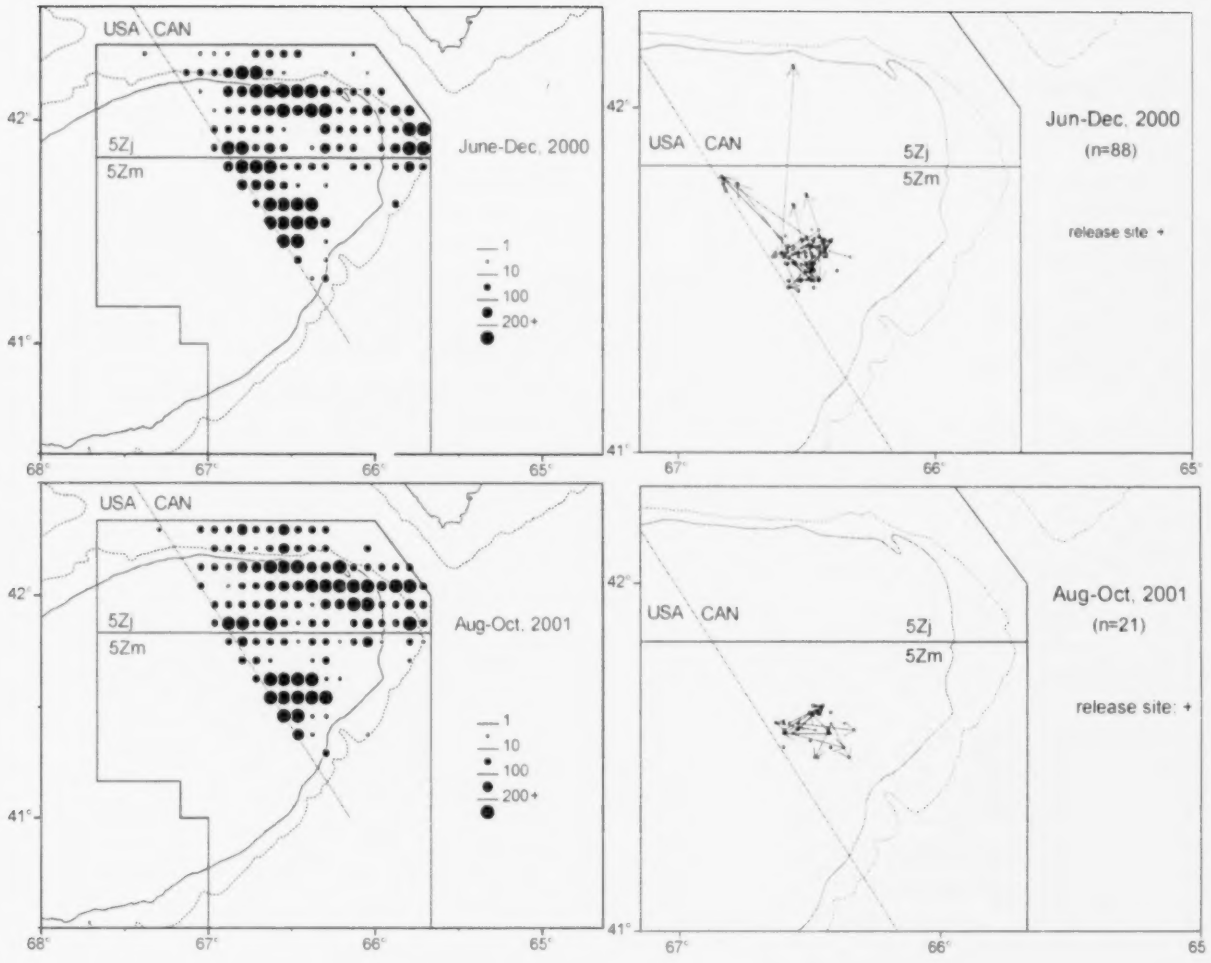


Figure 2a. Distribution of mobile gear fishing effort (total hours fished per 5 minute square) for cod, haddock and yellowtail flounder directed trips and yellowtail flounder recaptures for 2000 and 2001 from 1999 releases in the Yellowtail Hole.

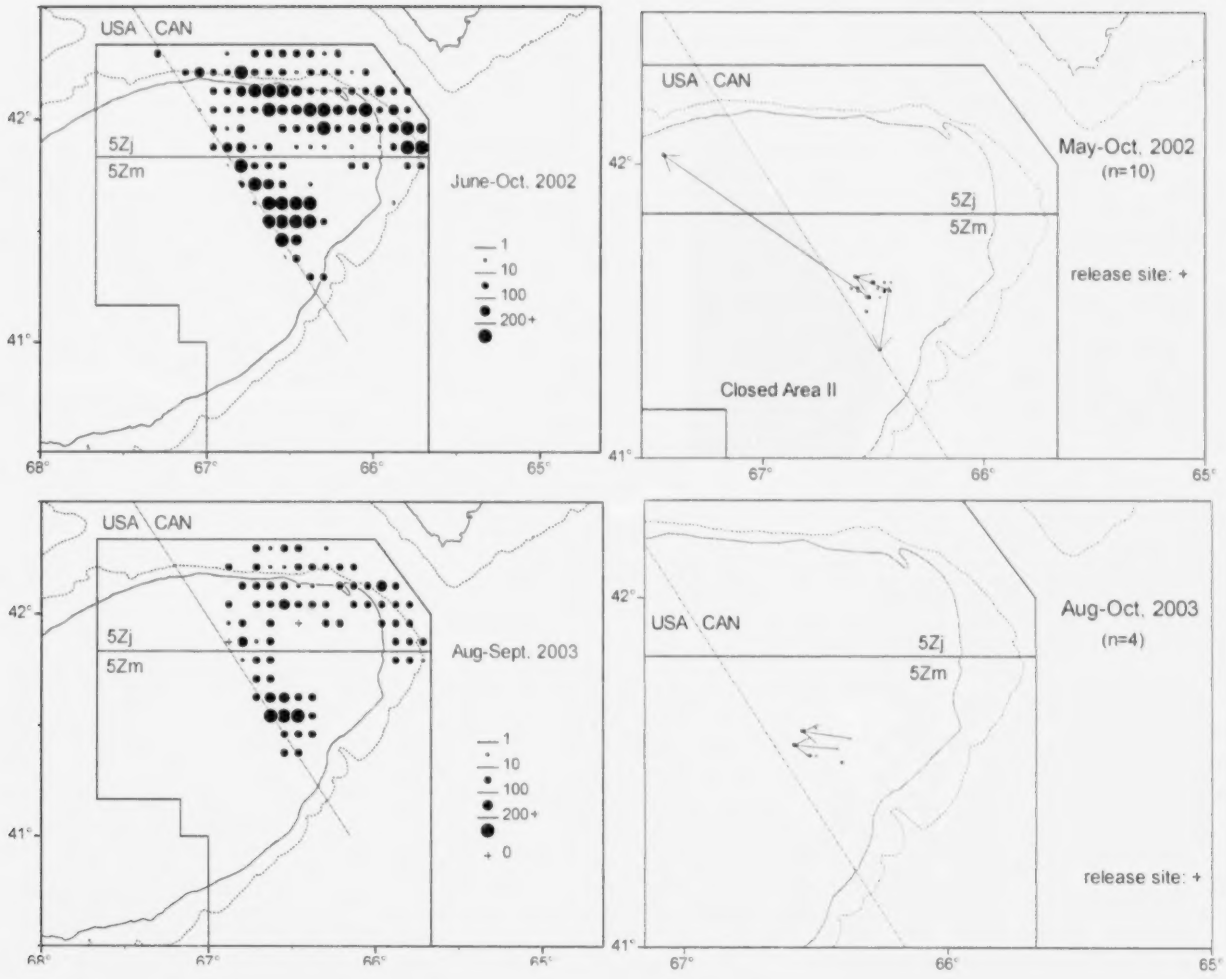


Figure 2b. Distribution of mobile gear fishing effort (total hours fished per 5 minute square) for cod, haddock and yellowtail flounder directed trips and yellowtail flounder recaptures for 2002 and 2003 from 1999 releases in the Yellowtail Hole.

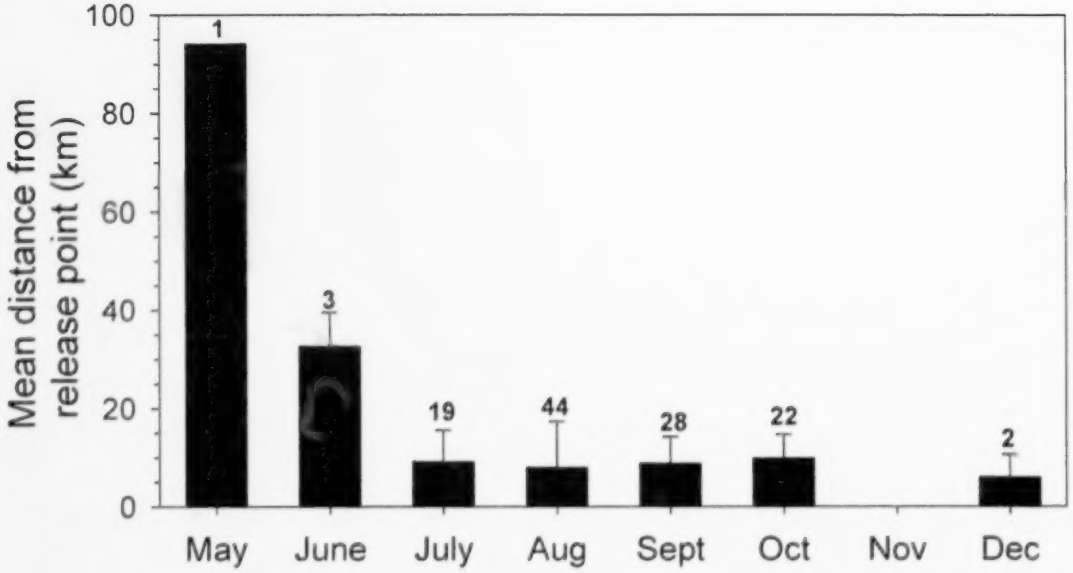


Figure 3. Mean distance from release position (km) by month (+1 standard deviation) for yellowtail flounder recaptures reported in 2000-2003 from Yellowtail Hole releases in 1999. The total number of recaptures for each month is indicated at the top of each bar.

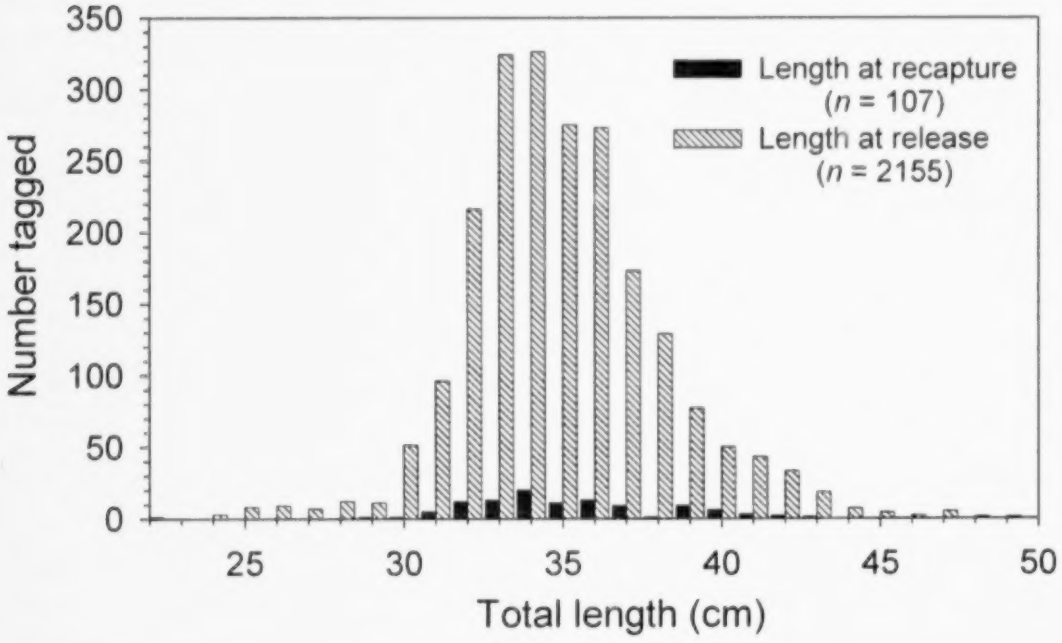


Figure 4. Length composition of yellowtail flounder tagged and released on Georges Bank in December, 1999 and reported lengths for recaptured fish, 2000-2003.

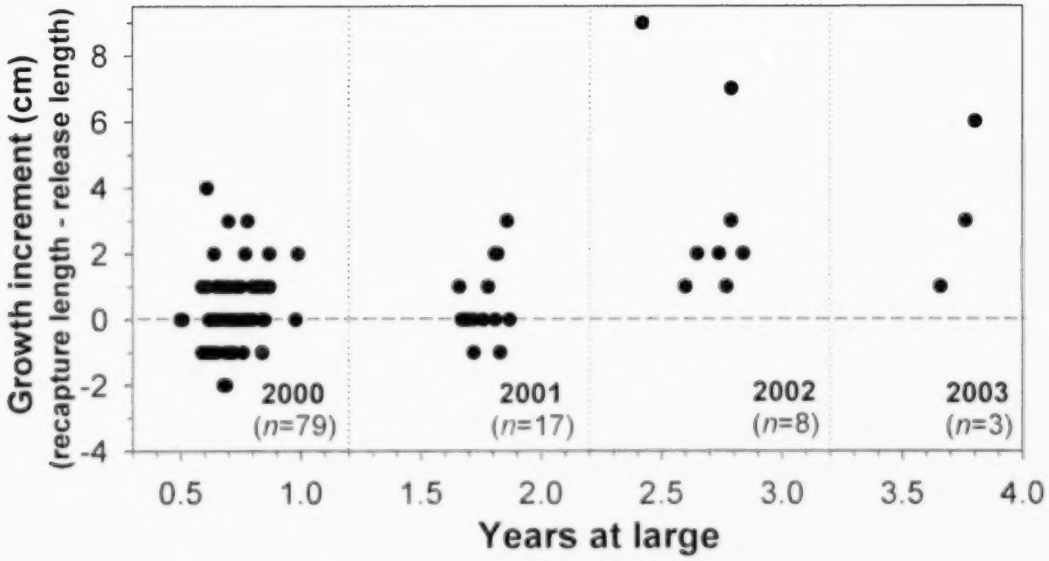


Figure 5. Growth increment (cm) of yellowtail flounder based on the difference between total length measurements at release and recapture for fish tagged in the Yellowtail Hole on Georges Bank in 1999, and subsequently recaptured in 2000 through 2003.

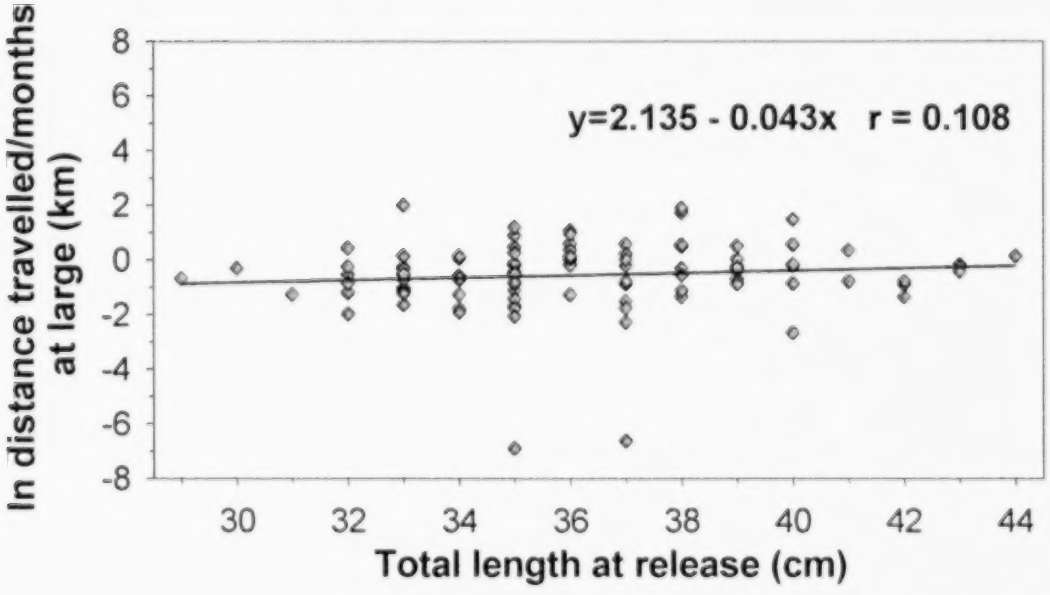


Figure 6. Natural log of distance travelled per month (km) versus release length (cm) for yellowtail flounder tagged and released on Georges Bank in December, 1999. The regression predicting distance travelled per month based on length at release was not significant ($P$= 0.270, F=1.229, df=1, 104).

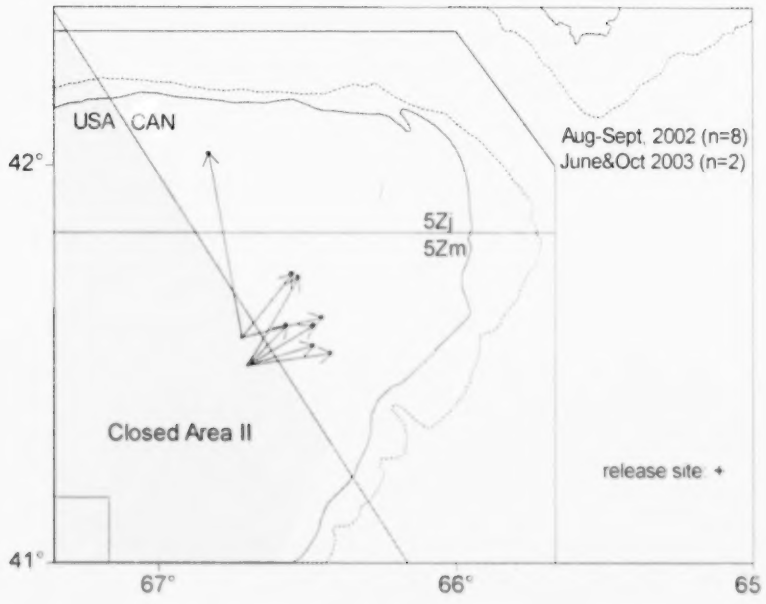


Figure 7. Location and direction of transboundary movements for yellowtail flounder tagged in Closed Area II on Georges Bank in February, 2002 and subsequently recaptured in the Yellowtail Hole during August-September, 2002 and June and October, 2003.

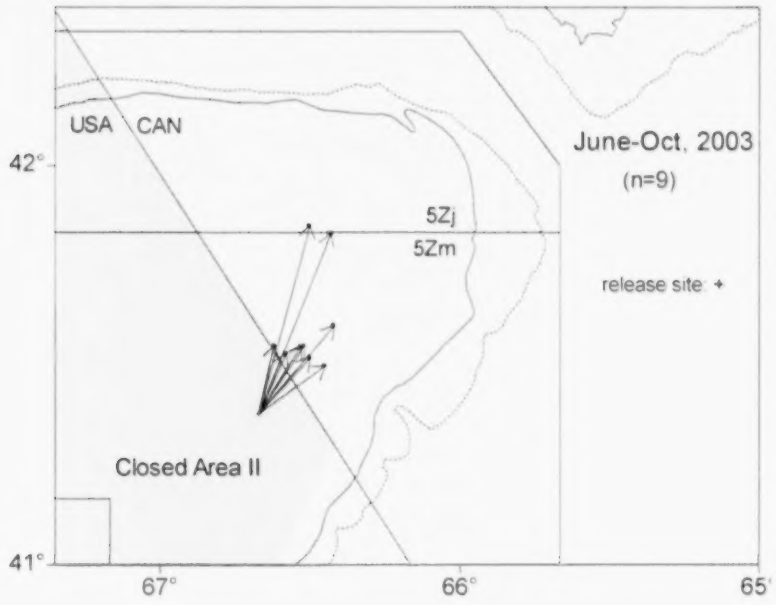


Figure 8. Location and direction of transboundary movements for yellowtail flounder tagged in Closed Area II on Georges Bank in February, 2003 and subsequently recaptured in the Yellowtail Hole, June-October, 2003.

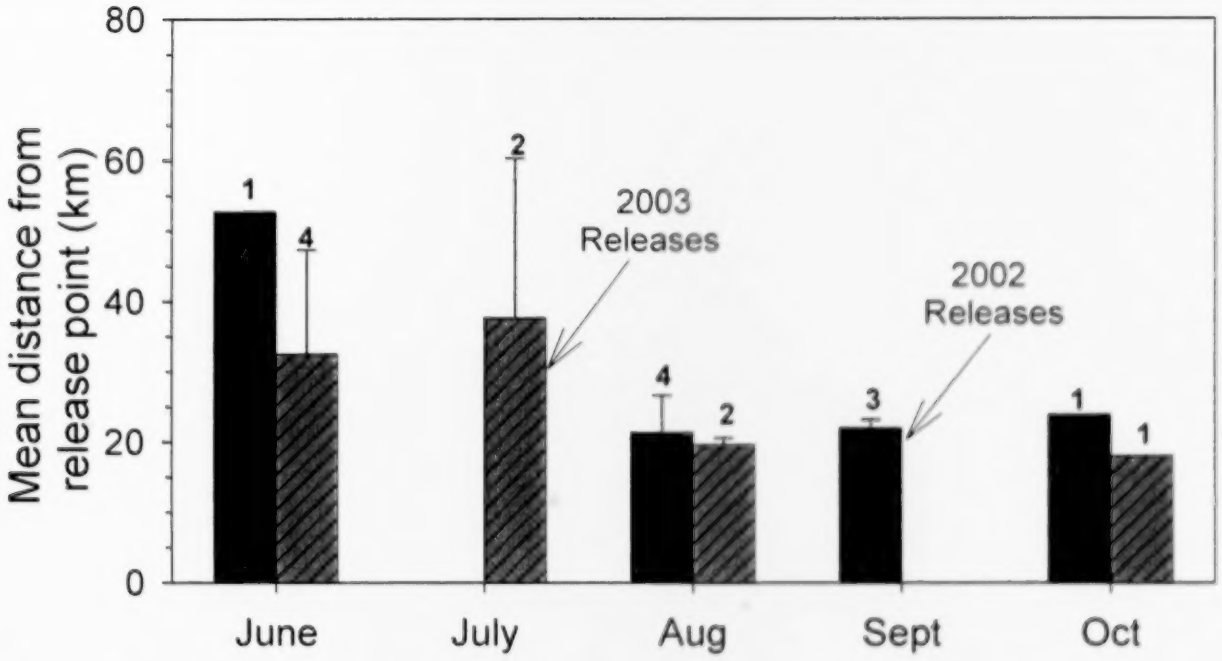


Figure 9. Mean distance from release position (km) by month (+1 standard deviation) for yellowtail flounder recaptures reported in 2002-2003 from Closed Area II releases in 2002 and 2003. The total number of recaptures for each month is indicated at the top of each bar.

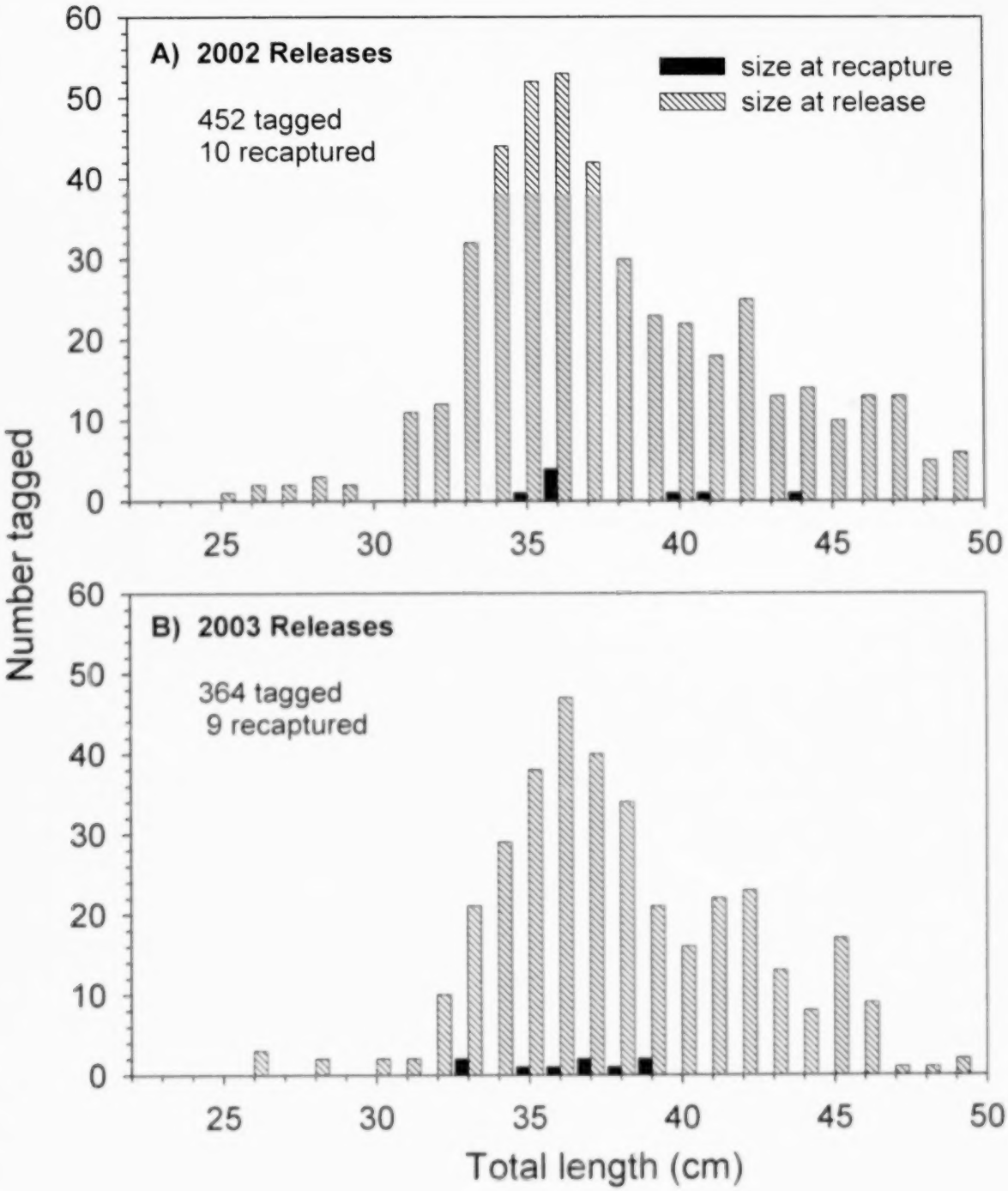


Figure 10. Length composition of yellowtail flounder tagged and released on Georges Bank in Closed Area II in 2002 (A) and 2003 (B) and reported lengths for recaptured fish.

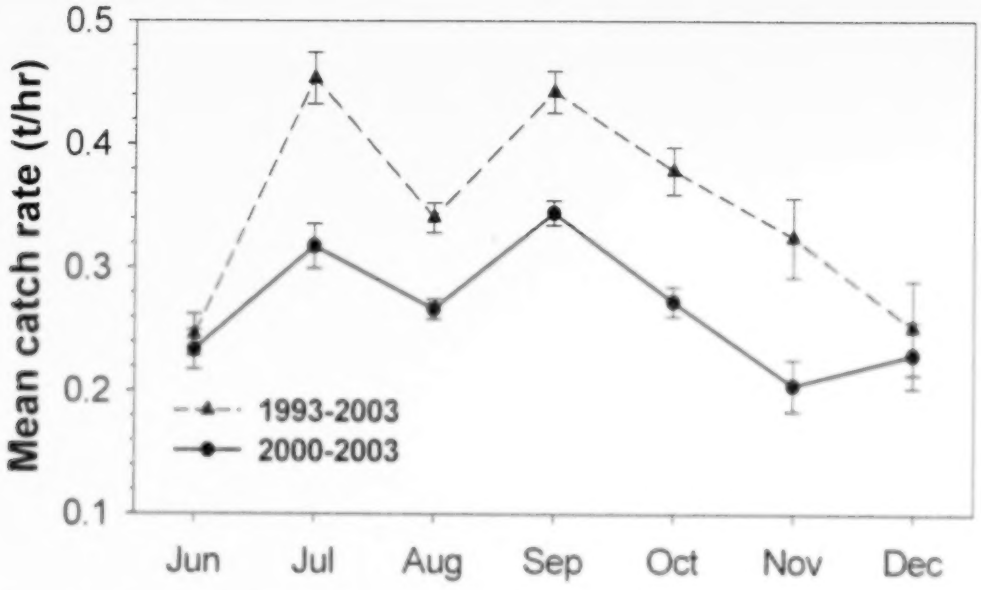


Figure 11. Nominal CPUE (mt/hour fished) by month for yellowtail flounder trips in 5Zm with ≥ 2.0 t yellowtail landed per trip for two time periods: the entire fishery (1993-2003) and the recapture period (2000-2003).

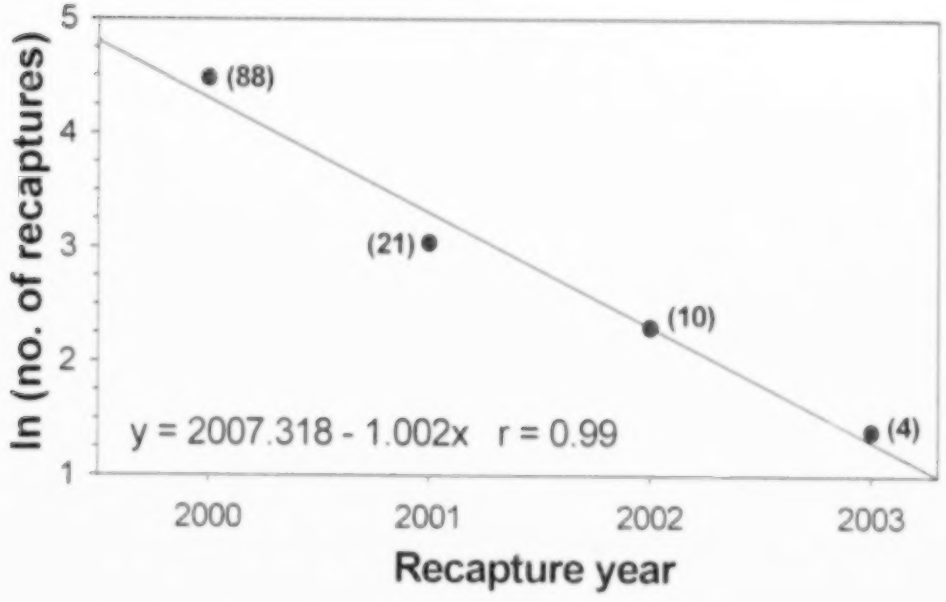


Figure 12. Natural log the number of recaptures per year versus recapture year (2000-2003) for yellowtail flounder tagged and released on eastren Georges Bank in the Yellowtail Hole in December, 1999. The regression predicting the number of recaptures based on recapture year was statistically significant ($P$= 0.010, F=96.323, df=1, 2).